Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

THE MUNICIPAL WATER SUPPLY OF MONTREAL[1]

By Thomas W. Le Sage[2]

Montreal, the commercial metropolis of Canada, has a population of about 700,000 inhabitants, making it under that heading the sixth or seventh largest center of population in North America. The city is situated on the island of that name in the St. Lawrence River and lies at the confluence of the St. Lawrence and Ottawa Rivers, whose waters meet at the upper end of the island. It is at the head of ocean navigation and to this fact its commercial supremacy is mainly due.

Founded in 1642, the city underwent many viscissitudes under French domination and its civic progresss really only dates from the beginning of the nineteenth century, and chiefly within the last 35 years, when the opening of new streets, the improvement of the highways, the erection of imposing public and private institutions have induced a large increase in population and marked prosperity to the City.

Montreal, within its administrative limits proper, comprises an area of about 28,400 acres and contains a population of 694,000. There are in Montreal two water supply systems, the municipal system supplying the main portion of the City, to the extent of about two-thirds of the above population, and a private system owned by the Montreal Water & Power Company, supplying about one-third of the population, besides two towns on the outside limits of the City.

Historical. Montreal's first attempt at water supply was made in 1801, when a company was formed to distribute water to the citizens through wooden pipes from springs in the mountain. About 1815, another company acquired the rights to supply water and establish pumping engines at the river front and put up a tank reservoir of 240,000 gallons near the citadel at a height of 97 feet above the river. In 1830 still another company acquired the rights, replaced some of the smaller piping by pipes of 10 inches diameter and replaced the steam pumping engines, in 1843, with others having a capacity of 93,000 gallons per hour.

---

[1] Read before the Montreal Convention, June 22, 1920. Discussion is invited and should be sent to the Editor.

[2] Engineer, City Water Department, Montreal, P. Q., Canada.

The city became possessor of the water works through purchase in 1845, for the sum of 50,000 pounds. The city enlarged the works, constructing a reservoir of 3,000,000 gallons capacity on the Coteau Baron (now St. Louis Square), at a height of 130 feet above the river, and extended the piping system, so that by 1850, there were 19 miles of cast iron pipes and about 6 miles of lead pipes and the expenditure had been 30,000 pounds since the acquisition of the works.

In 1852, after a serious fire which destroyed part of the city had shown the inadequacy of the water supply, a report was prepared by T. C. Keefer recommending a water supply from the head of the Lachine Rapids, with an open canal 4½ miles long with sufficient fall to supply the water and hydraulic power to pump 5,000,000 imperial gallons per day to the proposed McTavish Reservoir at an elevation of 204 feet above the River. These works were carried out and put into operation in 1856. The supply had to be supplemented by steam pumps in 1868, as the city's water consumption had outgrown the 5,000,000-gallon capacity of the hydraulic pumping supply.

Meantime the project of enlarging the old aqueduct to utilize the power for pumping sufficient water to meet the city's needs, came up at various times. Finally, in 1905, estimates were prepared for widening the aqueduct to develop water power sufficient to pump 50,000,000 gallons and to build an intake out from shore and a concrete supply conduit to bring water to the steam pumps, whilst the aqueduct was being widened. The works were begun and the concrete conduit put in operation in the fall of 1909, when the aqueduct was emptied and contracts let for its widening.

In 1910, before the contractors had completed the first widening, a further change of plans was made. This contemplated a still greater increase in the dimensions of the aqueduct, to afford sufficient water power to supply and pump 100,000,000 gallons per day. This project was put under contract in 1913, but was discontinued in 1916 as unprofitable, owing to various circumstances and change of conditions, such as the breaking out of the war and the reduced cost at which purchased power for pumping could be obtained, by reason of the great increase in water power development around Montreal since the aqueduct widening was first mooted.

These delays and interruptions in carrying to completion the aqueduct widening, will serve to explain the heteregeneous character of the main steam pumping plant at the present day. In 1909 it was surely thought that the city within three years would have its pumping done by water power to the extent of 50,000,000 gallons per day. Again, in 1911, after the changes in plans to enlarge the projected capacity from 50,000,000 to 100,000,000 gallons per day, it was again considered certain that within five years time, or by 1916, the city's pumping would be all done by water power, and the old steam plant could be left to be remodeled at leisure, to serve as reserve.

Meantime, the water consumption was increasing by leaps and bounds. In the four years 1910–1914, the daily average consumption increased from 38,670,000 to 55,750,000 gallons per day, or over 44 per cent, a greater rate of increase than it had shown in the preceding nine years. During this time steam pumps and boilers were added from year to year, as the wants required and as expediency suggested, within the restricted limits of the pumping station area.

General features of works. The city's water supply is drawn from the St. Lawrence River about a mile above the Lachine Rapids and a distance of about 5 miles from the city. The supply intake is 1200 feet from shore, the river at this point being about three-fourths of a mile wide. The water is brought down by gravity a distance of 5¼ miles to the main pumping station, through a covered concrete conduit, circular in shape with flattened invert, practically of 8½ feet in diameter, having a capacity at the lowest stages of the river, of 80,000,000 imperial gallons per day.

At the lower end, to the south of this supply conduit, is the filtration plant, to which the water is led by gravity. Raised by low-lift pumps to the prefilters, the water flows thence to the final filter beds and the filtered water reservoir, being repumped from there to the level of the suction well feeding the main supply pumps. The filtration plant, of 50,000,000 imperial gallons capacity at present, filters only about three-fourths of the water supplied the pumps. Plans for its enlargement are under way. The whole supply is, however, sterilized by hypochlorite.

The main or low-level pumping station situated at the end of the supply conduit, near the southwestern limits of the city, has a pumping capacity of 108,000,000 imperial gallons per day, by means of eight steam pumping engines as follows:

Pumping engines Nos. 1, 2 and 4 of the horizontal reciprocating type, Worthington Duplex high duty steam pumping engines with combined daily capacity of 30,000,000 gallons.

Pumping engines Nos. 3, 5, 6 and 7 of the centrifugal type, high lift pumps, direct connected to high speed vertical triple expansion engines working at 350 revolutions per minute with combined daily capacity of 48,000,000 gallons.

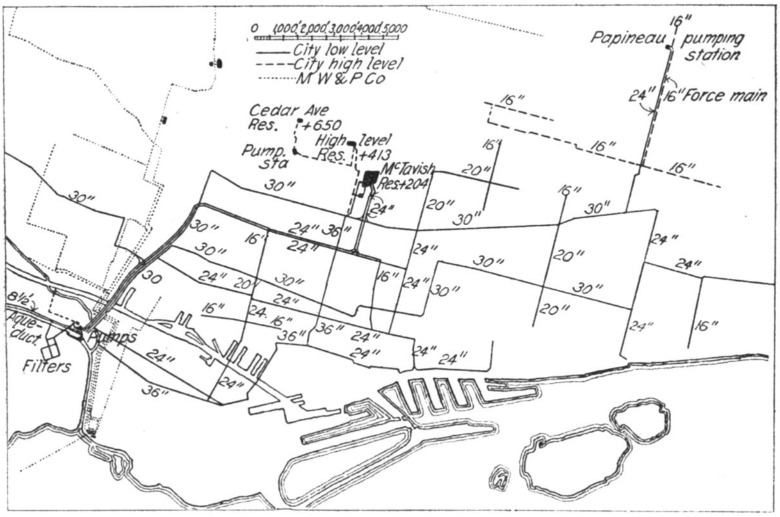

FIG. 1. MAP OF THE LARGER MAINS IN THE CENTRAL PART OF THE CITY

Pumping engine No. 8, a DeLaval centrifugal high lift pump geared to steam turbine, with daily capacity of 30,000,000 gallons.

The oldest of these pumps, Nos. 1 and 2, were installed in 1886 and 1893 respectively. They are the least efficient of the pumping plant and are to be replaced within a year by two 30,000,000 gallon electric driven high lift centrifugal pumps now contracted for. No. 4 pump installed in 1905 is of more modern type with a trial duty test of about 160,000,000 foot-pounds. The four high lift centrifugal pumps driven by direct connection to triple expansion vertical engines of enclosed type, at 350 revolutions, installed from

1909 to 1913, are representative of the change from the reciprocating to the high lift centrifugal type of water works pumping engines. Their efficiency rating on trial was from 108,000,000 to 114,000,000 foot-pounds duty. Their compactness, simplicity and freedom from the number of moving parts in the reciprocating type, as also their adaptability for working under variable loads, have shown them to be a very reliable type of water works pumping engine.

These centrifugal pumps discharge the water through the force mains against the reservoir head and into the City's distribution system. There are six pumping force mains; one of 36 inches, two of 30 inches and three of 24 inches. The 36-inch and two twenty-fours connect directly with the reservoir; the others feed into the distributing service pipes throughout the city as well as being indirectly connected with the reservoir. Thus the system may be said to be direct pumping with regulation of pressure due to the head from a reservoir of limited capacity.

The main reservoir, McTavish Reservoir, situated at the head of McTavish Street on the slopes of Mount Royal about 1½ mile from the pumping station, has its water surface at elevation 204 above low water level of the harbor. Its capacity is 37,000,000 imperial gallons or about four-sevenths of last year's average daily consumption of 65,000,000 imperial gallons.

From the early settlements along the river front, the natural expansion of the city was towards the slopes of Mount Royal. In configuration the city is laid out in main thoroughfares paralleling the river, the cross streets rising towards the mountain in gentle grades to the level of Sherbrooke Street, beyond which begins the slope of the mountain. The elevation of Sherbrooke Street at McTavish Street is 120 feet above the river and the distance from it some 6000 feet.

The business or commercial section of the City lies principally in the lower levels of the city. The pressure head due to the McTavish reservoir supplies the system up to about elevation 130 above the harbor, furnishing water pressures of 80 pounds in the pipes of the downtown district to 35 pounds at the level of Sherbrooke Street.

High-level system. Above Sherbrooke Street and generally in that area spread out around the eastern slope of the mountain, extends the high-level system. The high-level or Peel Street reservoir situated on the Mountain slope at the head of Peel Street has its water surface elevation at 422 feet above the harbor. Its capacity is 1,750,000 imperial gallons. The high-level system is supplied by repumping the water from the McTavish reservoir level. There are two pumping stations for this purpose; the McTavish Street and Papineau Avenue Stations. The pumping is done by high lift centrifugal electric driven pumps, with two units one of 6,000,000 and one of 5,000,000 imperial gallons in each station. The average daily consumption for 1919 of the high-level system was 11,900,000 imperial gallons.

Upper-level system. To provide for water supply to the still higher residential district of Cedar Avenue and Redpath Crescent, confined in area by the limits of Mount Royal Park, the upper-level system was installed about nine years ago. This consists of a covered reservoir of 200,000 gallons capacity, hollowed out in the Mount Royal Park at elevation 550[3] above the harbor. The water is repumped from the high-level system to this upper level by a duplicate set of electrically driven units, each of a capacity of 150,000 imperial gallons per day.

To supply the high levels of Notre Dame de Grace ward, annexed to the City in 1910, there is also provided a booster pumping station on Western Avenue to repump the water from the main low-level system. The pumping is done against the pressure head due to three tanks of 100,000 gallons capacity erected on the highest point in the ward at elevation 382 above the harbor. The daily average consumption is about 2,500,000 imperial gallons.

The town of Cartierville, annexed in 1917 and forming part now of Ahuntsic-Bordeaux ward, has its own water supply plant of 1,000,000 gallons capacity, consisting of electric driven centrifugal pumps and filtration plant; this independent supply is taken from the back river at Cartierville.

The former Town of Emard, annexed in 1910 and now part of St. Gabriel Ward, has also an independent supply, the water being taken from the city's main supply conduit and pumped, under contract, by an outside company. The average daily consumption is about 935,000 imperial gallons.

Water distribution system. The city's distribution system of piping comprises 497.6 miles of pipes from 4 inches to 36 inches as follows:

---

[3] The reservoir is incorrectly given an elevation of 650 ft. in Fig. 1, an error discovered too late for the map to be changed.

SIZE	MILES OF PIPE	PERCENTAGE OF TOTAL
4	54.0	10.85
6	63.0	12.66
8	203.75	40.95
10	48.62	9.77
12	79.47	15.97
16	16.0	3.21
20	3.55	0.71
24	16.6	3.34
30	9.55	1.92
36	3.06	0.62
	497.6	100.00

Of this total it will be noted that the 8-inch, 10-inch and 12-inch pipe make up about 332 miles or about two-thirds of the whole. For many years past the principle has been adopted that no pipe less than 8 inches diameter shall be laid for distribution service in the streets of the city. The mileage of 4-inch and 6-inch pipes shown in the table is mostly in outside wards annexed to the City within the past ten years. The smaller pipes in the system are generally well supported at intersecting streets by pipe of larger diameter, especially in the main portion of the City, thus providing for several effective hose streams in case of fire without the use of fire engines.

Filtration plant. In the city plant a double system of filtration is carried out, that is, the water is first passed through roughing prefilters before being passed through the regular filter sand beds.

The raw water is taken from the main supply conduit through a 9-foot circular conduit about 1200 feet from the lower end of the supply conduit and is lifted by motor-driven low lift pumps to the prefilters.

There are 16 covered prefilters, each of a net filtering area of 1200 square feet. The water passes through the prefilters at a normal rate of 115,000,000 imperial gallons per acre per day. From the prefilters the water flows by gravity to the final filters. There are 16 covered final filter beds with a total area of 6 acres. The water passes through the final filters at a normal rate of about 8,500,000 imperial gallons per acre per day and collects in the covered filtered water reservoir, which has a capacity of 6,000,000 gallons.

The filter plant, as already stated, has a normal capacity of but 50,000,000 imperial gallons per day, and as the water consumption has reached 65,000,000 to 70,000,000 gallons it is necessary to enlarge it. Plans for this work are under way, and land is available for such extension.

Quality of the water. The water drawn through the intake 1200 feet from shore at the head of the Lachine Rapids is mainly of St. Lawrence River origin. However, as the Ottawa River joins the St. Lawrence at the head of Montreal Island, its water follows the shore line inside the intake and at times the supply contains varying proportions of Ottawa water, depending on seasonal and weather conditions. The largest percentage of Ottawa water occurs in May and its presence is always indicated to the consumer by its characteristic brown color. Except in April or May, when it carries a high turbidity, this is its only objectionable feature.

The water of the St. Lawrence, from the standpoint of household use, as tapped by the intake 1200 feet from shore, is superior in every respect to that found further inshore, and the bacterial content, turbidity and color increase as the shore is approached.

The percentage of Ottawa water present in the City supply is indicated by a simple test determining the alkalinity of the mixture in parts of calcium carbonate per million.

The following tabulation of the physical and chemical characteristics of the water supplied during 1919, have been furnished by John H. Harrington, chemist of the Water Department.

Physical Characteristics, 1919

		HIGH	LOW	AVERAGE
Percentage Ottawa water		47 (May	None (Feb.)	16
Turbidity		29 (April)	7 (Feb.)	15
Color		38 (May)	6 (Feb.)	18
Bacteria per cc. 96 hours at 20°	Raw	12,900 (Dec.)	320 (Aug.)	4,600
	Chlorinated	57 (Mar.)	8 (Sep.)	19

Chemical characteristics, monthly summaries, 1919; parts per million

	HIGH (FEB.)	LOW (MAY)	AVERAGE
(1) Total solids	150.0	110.2	124.5
(2) Alkalinity (calcium carbonate)	100.0	62.0	87.0
(3) Magnesium carbonate	6.0	4.6	5.5
(4) Sulphates and chlorides of calcium and magnesium	16.0	9.5	13.7
(5) Oxygen absorbed. Organic and other oxidizable matter	3.5	9.0	5.5
(6) Chlorine (combined)	6.0	3.7	5.2
(7) Increase of total hardness due to addition of hypochlorite	1.2	0.24	0.70
(8) (7) expressed as percentage of (2)	2.0	0.24	0.80

Water consumption. The average daily consumption for 1919 was 65,046,000 imperial gallons. The estimated population served by the City's system was 449,000, giving a per capita daily consumption of 145 imperial gallons.

Figure 2 shows the average daily consumption of water for each year for the last 20 years, also the population served and the per capita daily consumption each year, also the area of the City served with water from the City system.

From 1900 to 1919 the average daily consumption has increased from 20,412,000 to 65,046,000 gallons, that is, 44,634,000 gallons or 218 per cent. In the same period, the population served has increased from 266,000 to 449,000, that is, 183,000 or 69 per cent.

From 1900 to 1910 the average rate of yearly increase of consumption was 1,822,000 gallons per day, an average of about 6.6 per cent increase each year. From 1910 to 1914 the average yearly rate of increase was 4,270,000 gallons per day, or an average increase each year of 9.6 per cent over the preceding year.

In 1914 to 1916 the rate of consumption remained stationary at about 55,500,000 gallons per day, but in 1917–1918, for two years, it rose again at a rate of increase of 4,760,000 gallons per day per year, and in 1918–1919 remained stationary at about 65,000,000 gallons for each year. The population served from 1912 to 1919 has increased 110,000, that is, from 339,000 to 449,000, or 32.6 per cent.

The consumption per capita between 1910 and 1914 jumped up from 115½ gallons in 1910 to 150 gallons in 1914 and it has been between 140 and 150 gallons practically since 1912.

It is difficult to explain this increased rate of consumption of water in the past ten years. It is no doubt partly due to more ample use of water in modern house fittings but it may also be explained by the greater use in manufacturing establishments and the greater quantities required for municipal purposes, public baths, parks and squares and the flushing of sewers and streets, all of which have greatly increased in the past ten years.

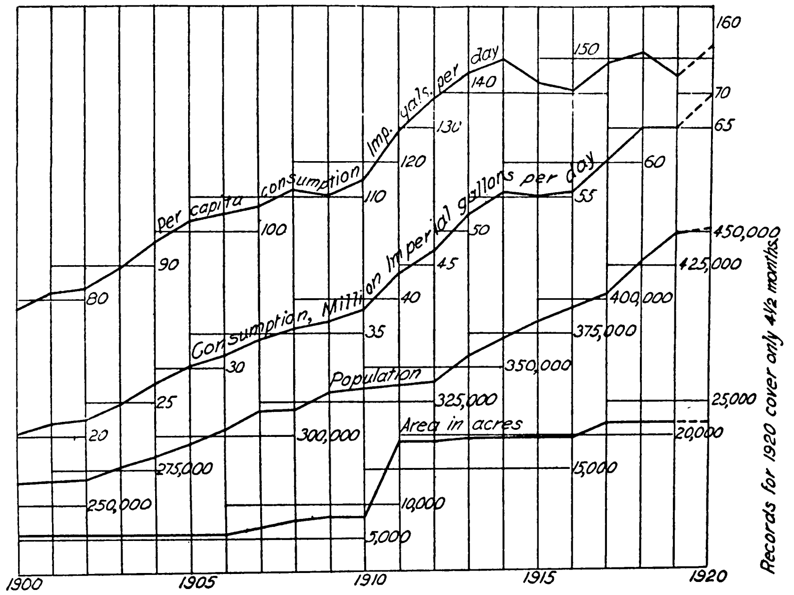

Fig. 2. Consumption Data

Water rates and meters. The charge for water to the citizens is met by a municipal tax on all householders of 6 per cent on the assessed rental. This tax is commonly called the water rates, but it does not necessarily represent the cost of the water services. This flat rate method of charging for water is not conducive to economy from the operating point of view. The citizens have no direct inducement to economize on water and it calls for more rigid house to house inspection of fixtures, if wastage is to be controlled.

Meters are only placed in certain commercial and manufacturing establishments and other institutions where the use of water requires control against wastage. There are about 85,000 water services and only 1668 meters in use; that is less than 2 per cent of services are metered.

The meter rate regardless of the quantity of water used is $1.15 per 1,000 cubic feet or about 18½ cents per 1000 imperial gallons. For fire protection no charge is made for water used. The proprietor may install fire protection services of 4, 6, or 8 inches on his premises for sprinkler or standpipe supply, by paying the whole cost of laying the service, and excepting in certain manufacturing establishments which are served all by meter, no charge is made for the water used for this service.

At present the city has under consideration many extensions to its water works plant. Two 30,000,000-gallon electrically driven pumps are contracted for to be delivered within a year. Plans are being prepared for enlarging the filtration plant to a capacity of 130,000,000 gallons per day. To supplement the present limited conduit supply of 80,000,000 gallons, the aqueduct is to be prepared for service to convey additional water and also furnish power in a modified form. Additional reservoir capacity and an increase in the number of force mains are also projected in the near future.